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# MARTEN (*MARTES AMERICANA*) AND TIMBER MANAGEMENT IN NORTHWESTERN ONTARIO:

# A LITERATURE REVIEW

by

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Final responsibility for the content rests with the authors.

## INTRODUCTION

Forest Management practices alter the age distribution of stands through timber harvest and the species composition through planting programs and tending. The effect of timber operations on wildlife depends upon the habitat requirements of the species. Habitat in this case refers to all the environmental variables which provide for the life requirements of the animal.

Marten (Martes americana) habitat requirements are best met in mature coniferous or conifer-dominated mixed wood stands with a canopy closure greater than 30%. These stands contain numerous snags and windfall logs that offer denning opportunities and access below snow cover for winter hunting. Population dynamics, reproduction and territorial behavior (Strickland and Douglas 1987) will reflect habitat quality and quantity which in turn reflects timber management practices and forest stand types. A Habitat Suitability Index (Allen 1982) describes the various ecosystem components that combine to produce habitat for marten.

This literature review summarizes the level of knowledge of how and why marten respond to timber management operations, with an emphasis on information pertinent to northwestern Ontario.

## POPULATIONS

Marten exhibit a ten year cycle of population peaks (de Vos 1951b, 1952). Since the 19th century, the amplitude of these peaks has greatly decreased. This cycle does not appear to be dependent solely upon the availability of food (Cowan and MacKay 1950, Lensink et al. 1955) because marten will become more diverse in their food habits as principal prey

populations decrease (More 1978). However, in the short-term, marten populations follow changes in microtine populations (Weckwerth and Hawley 1962). If overall food resources become limited, marten will disperse from their usual home ranges thereby reducing population density in some areas (Thompson and Colgan 1987c) and increasing it in others.

At the turn of the century, decreasing populations of marten were caused by over-trapping and changes in forest structure as a result of extensive logging operations, forest fire, and settlement (de Vos 1952, Mech and Rogers 1977, Raine 1981). Yeager (1950) and Bergerud (1969) suggested that the major factor contributing to this population decline was the destruction of preferred marten habitat by logging however, Marshall (1951) believed that the limiting factor for marten in the past century was trapping because marten never developed a fear of traps.

Timber harvest by clearcutting results in reduced densities of marten (de Vos 1951a, 1952, Bergerud 1969, Soutiere 1979, Steventon 1979, Steventon and Major 1982, Thompson and Colgan 1987a). This reduction may be as much as 60% below an undisturbed or limited disturbance site (Strickland and Douglas 1984). Partial timber harvesting (50 - 80% basal area reduction) had little effect on use by marten (Soutiere 1979, Steventon and Major 1982). A minimum of 25% of the forest area must remain as blocks of undisturbed pole-stage and larger conifer dominated stands to sustain a marten population (Koehler and Hornocker 1977, Soutiere 1979). The minimum size of stands is unknown.

Logging also affects marten populations by creating access to wilderness areas. Population densities in accessible areas of the same forest were less than that of populations in inaccessible areas (Marshall

1951, Raine 1981) which may have been due to increased trapping pressure, increased susceptibility to trapping or other undocumented factors relating to human disturbance.

## HOME RANGES

Marten home range boundaries often coincide with edges of topographic or vegetative features such as large open meadows, burns and streams (Hawley and Newby 1957). Winter home ranges are often larger than summer ones (Steventon 1979, Steventon and Major 1982) and home ranges for males are usually larger than those for females (Hawley and Newby 1957, Mech and Rogers 1977). Males will tolerate overlapping of home ranges with females but not with other males (Hawley and Newby 1957).

Marten home ranges can contain a number of forest cover types including undisturbed and harvested stands (Koehler and Hornocker 1977, Soutiere 1979) but females are predominantly found in mature forests (Steventon 1979, Steventon and Major 1982). While a certain amount of variety occurs in a home range, most activity is in or near mature mesic spruce/fir stands with canopy cover greater than 30% (Koehler and Hornocker 1977). Very open sites, wet or dry, are not used in proportion to the availability of such habitats on a given area (More 1978).

Following commercial clear cut of a forest, marten home range size increased for both males and females (Thompson and Colgan 1987b, 1987c). However, partial clear cutting did not appear to shift marten home ranges (Soutiere 1979) even during active logging operations. Reduced food

resources also cause an increase in home range size (Thompson and Colgan 1987c) suggesting that food is a limiting factor, independent of cover, in determining marten home range size. Female home ranges are especially affected by changes due to clear cut logging and/or depletion of food resources; their home ranges will become greater in size than those of males under the same stressed conditions (Thompson and Colgan 1987c).

Within each home range, core areas can be identified in which marten concentrate hunting activity (Marshall 1951, Hawley and Newby 1957, Mech and Rogers 1977, Thompson and Colgan 1987b). Males generally have more core areas than females because of larger home range size. In logged sites, the core areas became further apart, increasing both distance and travel time. The number of core areas for males did not vary significantly among poor food years or on logged sites, but the number of core areas for females increased on logged sites (Thompson and Colgan 1987b).

## TRAVEL

Vegetation cover may influence marten travel behavior. Marten tend to avoid openings, especially in winter and travel across openings is linear and swift (Robinson 1953, Hawley and Newby 1957, Herman and Fuller 1974, Koehler and Hornocker 1977). Females have been observed in winter to follow tree cover around an opening that males would readily cross (Steventon 1979, Steventon and Major 1982). These openings will be used in summer if food is available (Koehler and Hornocker 1977).

In areas with dense forest cover, travel occurs in erratic zig-zag movements so marten can investigate subnivean spaces or windfalls for prey (Francis and Stephenson 1972, Soutiere 1979, Thompson and Colgan 1987b). Marten are not arboreal but will climb trees to escape predators or for denning (Marshall 1951, de Vos and Guenther 1952b, Francis and Stephenson 1972).

Marten movements tend to decrease in wet and very cold weather (Lensink et al. 1955, Strickland and Douglas 1984, Thompson and Colgan 1987a) but More (1978) found the opposite to be true.

Snow depth does not appear to have a major influence on marten travel (Francis and Stephenson 1972, Raine 1982). In winter, marten travel alone but several individuals may use the same travel routes (Marshall 1951, Quick 1953, Herman and Fuller 1974, Raine 1981) Marten may also use trails of other animals or snowshoe trails when available (Francis and Stephenson 1972, Raine 1982).

## FOOD REQUIREMENTS

Marten have a diversified diet with some items being consumed regularly, some seasonally and some erratically or occasionally. Small mammals are common in the diet while birds and bird eggs, insects, fruit, and berries are used seasonally (Cowan and MacKay 1950, Lensink et al. 1955, Weckwerth and Hawley 1962, Francis and Stephenson 1972, Soutiere 1979). Mice and voles are the principal food items, particularly Clethrionomys gapperi and Microtus spp. (Cowan and MacKay 1950, Lensink et al. 1955, Koehler and Hornocker 1977, Soutiere 1979, Strickland and Douglas 1984) but Peromyscus spp. were not favoured even when their

numbers were abundant (Francis and Stephenson 1972, More 1978). Carrion is not important to the diet (Cowan and MacKay 1950) but marten have been known to feed on it (Marshall 1951, Lensink et al. 1955). Thompson and Colgan (1987a, 1987c) suggest that larger prey such as snowshoe hare (Lepus americanus) and ruffed grouse (Bonasa umbellus) become increasingly important in winter or when small prey are scarce.

A decrease in small mammal numbers will result in declining marten populations (Hawley and Newby 1957) but the cyclic nature of the population is not solely dependant upon small mammal populations (Weckwerth and Hawley 1962, Thompson and Colgan 1987c). Marten will also diversify their diet by preying on other species (Cowan and MacKay 1950, More 1978) and enlarge their home ranges (Lensink et al. 1955, Weckwerth and Hawley 1962, Thompson and Colgan 1987c) in response to reduced food supply. Lower ovulation rates may also occur in females 1 and 2 years old resulting in fewer offspring (Weckwerth and Hawley 1962, Thompson and Colgan 1987c).

Clearcutting will alter prey habitat resulting in a possible change in prey species composition but little change in overall density of small mammals. Populations of Clethrionomys gapperi decreased but populations of Peromyscus spp. increased (Martell and Radvanyi 1977, Soutiere 1979). Soutiere (1979) found Microtus spp. ground-nesting birds and raspberries to be more abundant in the diet after cutting. Another favorable effect of clearcutting, particularly small clearcuts (<100 ha), is that diverse habitats for small mammals are created, much as fires formerly did (Ramerez and Hornocker 1981).

## HABITAT

Marten habitat is typically described as relatively mature mesic stands of conifer trees or conifer dominated mixed stands with greater than 30 percent canopy closure in Montana (Koehler and Hornocker 1977), Ontario (de Vos 1951b, Strickland and Douglas 1984, Taylor and Abrey 1982), Alberta (More 1978), Minnesota (Mech and Rogers 1977), and Colorado (Yeager and Remington 1956). Conifer ridges (Raine 1981), cedar swamps (de Vos and Guenther 1952), and white spruce dominated stands (More 1978) were locally important habitats in some studies.

Earlier successional stages tend to be avoided by marten, particularly aspen-birch stands (de Vos 1952). However, recently cutover and burnt stands may be used when sufficient cover is provided by adjacent stands (Soutiere 1979) and therefore, a diversity of forest types and successional stages may support an array of cover and food types favorable to marten (Koehler and Hornocker 1977). Open meadows and burns may be used more in the summer than in the winter (Koehler and Hornocker 1977) indicating that marten may be less restricted in habitat in the summer months (Marshall 1951, Hagmeier 1956).

Marshall (1951) and Mech and Rogers (1977) suggest that fire prevention programs can enhance marten habitat by preserving mature forest communities.

Timber harvest operations and silvicultural treatments perform the same role as fire in returning old growth forests to an earlier successional stage. Therefore, the evidence suggests that timber harvest itself would be detrimental to marten habitat if sufficient areas of cover are not left (Raine 1981, Thompson and Colgan 1987b). Soutiere

(1979) observed a certain amount of tolerance by marten of clear cut areas where the uncut residual stands became the nuclei of marten home ranges.

Management of marten should include both habitat management and trapping management to ensure adequate reservoirs of breeding animals (Thompson and Colgan 1987c).

## CONCLUSIONS AND RECOMMENDATIONS

Marten are inhabitants of mature or late successional stage conifer forests because of their capacity to provide shelter and desirable food supply, mainly microtine rodents. Forest disturbance which reverts the forest to an earlier successional stage will reduce marten populations by altering food supply, reproduction, and increasing home range size and dispersion.

Small cutovers have less effect on marten habitat use than large cutovers. Marten may utilize prey species in cutovers as well as fruit producing shrubs as long as sufficient shelter is available adjacent to them. Therefore clearcuts of less than 100 ha in size with a large amount of edge may actually enhance marten populations.

The effect of herbicides on small mammal populations has not been thoroughly studied but the reduction in fruit producing shrubs will reduce food supply although the introduction of grasses may increase the habitat suitability for Microtus sp.

Block cutting operations which permit timber harvest while maintaining a significant proportion of mature timber (25% or more of

area in blocks) will help maintain marten populations. Remaining timber should have high conifer content with at least 30% canopy closure.

Block cutting following the 100 ha clear cut guideline for moose habitat should maintain a substantial portion of marten habitat if pole stage is reached in the regenerating stands prior to harvest of the reserves and if the cut boundaries are irregular so that the majority of the cutover is within 100-200 m of uncut edge. Habitat is primarily a limiting factor for females which have smaller home ranges and a higher demand for old growth forest. Areas receiving high pressure for timber harvest should have trapping quotas carefully set to avoid local population decline.

## BIBLIOGRAPHY AND ABSTRACTS

Allen, A.W. 1982. Habitat suitability index models: Marten. USDI Fish and Wildlife Service. FWS/OBS-82/10.11. 9pp.

Habitat preferences and species characteristics of the pine marten (Martes americana) are described in this publication. It is one of a series of Habitat Suitability Index (HSI) models and was developed through an analysis of available scientific data on the species-habitat requirements of the pine marten. Habitat use information is presented in a review of the literature, followed by the development of a HSI model. The model is presented in three formats: graphic, word, and mathematical. Suitability index graphs quantify the species-habitat relationship. These data are then synthesized into a model which is designed to provide information for use in impact assessment and habitat management activities.

Author's abstract.

Bergerud, A.T. 1969. The status of pine marten in Newfoundland. Can. Field-Nat. 83:128-131.

By 1960 the martens home range in Newfoundland was no longer continuous. This is more threatened by the construction of a road in the western section of the province that will open up this vast region to logging operations. White pine is believed to be an important tree species for Newfoundland marten. The decline of the marten appears to be caused by logging destruction of mature forests and possible loss of pine forests through disease. The Terra Nova National Park does not have a marten population and may not have suitable habitat requirements. The wildlife Division of the Newfoundland Government should act to maintain this indigenous species from extinction.

Cowan, I.M.T. and R.H. MacKay. 1950. Food habits of the marten (Martes americana) in the Rocky Mountain region of Canada. Can. Field Natur. 64:100-104.

Marten in the Rocky Mountains consume berries, insects, birds, and especially mammals but avoid carrion. A preference for mice and voles over snowshoe hare and red squirrels was observed. Population cycles of marten are probably not induced by the availability of food.

de Vos, A. 1951a. Recent findings in fisher and marten ecology and management. Trans. 16th N. Amer. Wildl. Conf. :498-507.

Fisher and marten ecology and management were studied in Ontario. Fisher data was emphasized because relatively more information is already available on the marten. Fisher movements are more or less circuital but not restricted. The arboreal habits of fisher are not well developed in Ontario. The main prey species in winter are snowshoe hare, porcupine, fish, and mice; fisher also feed on deer and moose carrion. Both fisher and marten were absent from extensive recently logged and burned-over areas. The amount of cover is an important factor governing the level of survival of both species. Fisher appear to survive better in the early successional stages of the forest than the marten.

Survival and possible increase of both species may be achieved through a well-regulated trapping season instead of the present quota system in Ontario. A restocking effort made in Ontario in 1950 was successful.

de Vos, A. 1951b. Overflow and dispersal of marten and fisher from wildlife refuges. J. Wildl. Manage. 15:164-175.

Trappers' fur returns were analyzed in order to find indications of a possible overflow of fur-bearers from Chapleau Crown Game Preserve. Strong indications of such an overflow were found in the case of the marten and fisher.

Statistical analysis of the data concerning these two species prove that an overflow and a progressive falling off in abundance away from the Game Preserve exists in case of the marten. This could not be proven formally in case of the fisher. However, inspection of data show marked similarities in pattern for both species, namely a fall from a peak while progressing away from the Preserve. A second slight peak is caused by a surviving population outside the sanctuary.

Data presented indicate that in 1941 there were relatively high populations of both species in the zone adjacent to the Preserve as compared to low ones more remote from it. While during the period 1941-1947 a steep increase in population took place in the latter zone, this phenomenon was far less noticeable in the former. Consequently, remote areas have a more rapid increase in population than the already populated ones. As this increase is greater than expected by the logistic equation of population growth, and there is no known reason for expecting a differential reproduction, the differential increase is assumed to be partly due to influx.

Cyclic fluctuations are noticeable in the relatively low marten and fisher populations observed.

Author's abstract.

de Vos, A. 1952. The ecology and management of fisher and marten in Ontario. Ont. Dept. Lands For. Tech. Bull. 90pp.

A study of the biology and problems involved in the management of fisher and marten has been carried out in order to establish a sound management program in Ontario.

As no monograph has been previously published on fisher, the data on this species were emphasized. Information regarding the marten was presented only where it extended the data covered by other papers or where it was of value for comparison with the fisher.

The study was conducted in Ontario from January 1948 to April 1952. It consisted of field, library, and laboratory work. The major portion of the field work was done in Chapleau District.

A review was made of the taxonomic status of fisher and marten in North America. Color variations noticed in the pelts of both species were described.

The foraging movements of the fisher were found to be more or less circuital, but not restricted to a definite pattern. They were apparently governed by the availability of food, topography and cover, with the former (food) probably the most influential factor. Males appeared to have a wider home range than females. Movements varied with the seasons and were governed by weather conditions to an extent.

The fisher is diurnal in habits. It is less arboreal in Ontario than is generally indicated in the literature.

The fisher is fairly solitary in habits, although not to the extent which is commonly described. Young animals stay with the female until about February. Evidence of limited sociability between two or three adults was noticed for the period December to June.

The fisher uses a system of dens. Temporary dens are used for one to a few days, while more permanent ones may be used for several weeks or months. It burrows rarely and then only a few feet. It swims readily, and frequently may take to the water. Martens swim less often.

Analyses of fisher stomachs, intestinal tracts, and scats show that among the mammals snowshoe hare, porcupine, mice, and shrews may rank high as prey. Carrion of moose and deer may be eaten whenever available. Contrary to expectations the red squirrel ranks low on the list. Among the birds ruffed grouse were identified as prey. Spruce grouse were reported to be eaten. Berries are apparently eaten in quantities when

available; mountain ash and sarsaparilla berries were recovered. Fish may form part of the diet.
The fisher and the marten have few ecto- and endoparasites. Three new endoparasites were found for the fisher: Physalopteria (sp. unknown), Mesocestoides variabilis Mueller, and Ascaris devosi Sprent (sp. Nov.). The latter parasite was also found in several martens.

No clear-cut evidence was collected regarding competition of the fisher and the marten, and the amount of predation upon them by other predators.

A survey was made of the present and former status of fisher and marten in Ontario. Both were found most commonly in mature coniferous stands and a comparative study of the conditions for both species in different successional stages of the forest could not disclose any specific agent or complexity of factors influencing or controlling effectively their population levels. Their general absence in recently logged and burnt-over areas is probably the result of the combined effect of several factors, such as lack of cover, food, and denning facilities.

The number of fisher caught in Ontario has decreased to less than half the catch of the early twenties; that of marten to about one-sixth. The most probable factors involved in the decrease of both species are changes in their habitat from climax stands to second growth, and over-trapping.

A strong predominance of males was found among trapped martens in Ontario. This unbalanced sex ratio agrees with the findings of Yeager (1950). No abnormal sex ratios were found among trapped fishers.

Provisional age criteria were developed for the fisher. The best criteria for field use seem to be: greatest length of skull, zygomatic breadth, distance between temporal crests and length of sagittal crest.

The findings of this study suggest that certain management procedures might well be instituted. During the low phase of the population cycle of both species the harvest should be reduced in order to enable them to recover more rapidly from scarcity. The maximum allowable harvest in good habitat in Ontario on a sustained yield basis might be about one marten per two square miles and one fisher per six square miles. Restocking of depleted areas with martens can be undertaken successfully without heavy expenditure.

A comparative study was made between three study plots of 144 square miles each in different successional stages of forest cover in the Chapleau Forest District. One plot was selected in an area where no fishers and martens had been trapped since

the 1920's and where very drastic environmental changes caused by logging and burning had taken place. The second was chosen in an area where the forest type approached a climax condition and where both fishers and martens were being trapped in large numbers. The third one was selected in chapleau Game Preserve where no trapping pressure exists, and where the timber types were intermediate to those of the other plots. The numbers and population levels of the various species of mammals and birds present show marked differences between the plots.

Author's abstract.

de Vos, A. and S.E. Guenther. 1952. Preliminary live-trapping studies of marten. J. Wildl. Manage. 16(2):207-214.

This paper discusses the findings of live-trapping studies in restricted areas in Washington and Ontario. Marten tended to occupy a home range or foraging circuit. Movements are apparently mainly restricted to a territory close to the main watersheds. In Washington, the fir, cedar, and hemlock stand types seem to be preferred, while in Ontario the cedar-swamp type is most utilized.

Francis, G.R. and A.B. Stephenson. 1972. Marten ranges and food habits in Algonquin Provincial Park, Ontario. Ont. Min. Natur. Resour. Res. Rep. 91. 53pp.

An ecological study of the marten (Martes americana) was carried out in the deciduous forest region of Algonquin Park in central Ontario in 1951 to 1957. The distribution of marten and their ranges, movements, and densities were determined by a summer live-trapping program involving 573 captures in a 4.5 sq. mile (11.7 $km^2$) area. Males had an average home range of 1.38 sq. miles (3.58 $km^2$) which was three times the 0.44 sq. miles (1.14 $km^2$) occupied by females. These ranges consisted of one or more foraging ranges where marten confined their activities for a continuous period of time. Males had an average foraging range of 0.65 sq. miles (1.68 $km^2$) while females confined their activities to a much smaller area which averaged 0.29 sq. miles (0.75 $km^2$). Daily movements were in proportion to the size of their foraging ranges with males travelling further than females.

There was an overlap of the home ranges of males and females, but there was a spatial or temporal separation of resident animals of the same sex. Immature marten did not establish well defined ranges and none of these animals remained as a permanent resident in the area. When a range became vacant it was quickly reoccupied by an adult. The adult density remained constant during a 2-year period at 2 to 3 per sq. mile (0.8 to

1.2 per $km^2$). In the fall the transient immature marten increased the density to 3 to 5 per sq. mile (1.2 to 1.9 per $km^2$).

Marten were largely terrestrial in their activities and showed a preference in both summer and winter for forest types containing a high proportion of conifers.
The marten's summer food habits were determined from the analysis of 702 scats. Small mammals were the most important items in their diet, although other items were seasonably important in relation to their availability. In the spring, birds' eggs and young birds were important and in July and August berries were readily consumed. Insects and other invertebrates were also eaten when available. Among the small mammals there was a selection for Microtus which was eaten well in excess of its availability.

Authors' abstract.

Hagmeier, E.M. 1956. Distribution of marten and fisher in North America. Can. Field-Nat. 70:149-168.

The distribution of marten in North America is governed by the distribution of the northern evergreen forest. They have also been found in hardwood or mixed coniferous-deciduous forests. Fisher range is similar but not identical to marten. Both fisher and marten populations have decreased in the last century. Individual state and provincial distribution of marten and fisher are reviewed.

Author's abstract.

Hawley, V.D. and F.E. Newby. 1957. Marten home ranges and population fluctuations. J. Mammal. 38:174-184.

Information on home ranges and composition fluctuations of a marten population was obtained from a two and one-half year live-trapping study in Glacier National Park, Montana.

Eleven home ranges, six of males and five of females, were enclosed within the boundaries of the six square mile study area. The mean home range size of 0.92 square miles for males is significantly different from the mean of 0.27 square miles for the home range of females. Home ranges of adult marten of like sex showed a spatial distribution on the area. Resident marten tended to remain on the same home range for periods as long as 819 days with no seasonal movements observed. Some home range boundaries coincided with vegetative or topographic features.

The composition of the population was continually undergoing change through gain and loss of marten. The resident population initially increased in numbers from twenty-three in the summer of 1953 to twenty-seven in the winter of 1954, and then declined to a low of fourteen in the fall of 1951. Juveniles and adult females were involved most in the population decline. Three juvenile male marten were known to have dispersed from the population but the means whereby adults were lost from the area was not discovered. Evidence discussed suggests a period of overpopulation with food as the limiting factor in the habitat. Population densities computed for the study period were subject to considerable variation.

Authors' abstract.

Herman, T. and K. Fuller. 1974. Observations of the marten, Martes americana, in the Mackenzie District, Northwest Territories. Can. Field-Nat. 88:501-502.

Sight observations of 4 martens were made in the immediate vicinity of Heart Lake Biological Station between September 1973 and May 1974. There were two male-female pairs and social tolerances observed suggested a family relationship of some sort. The availability of supplemental food, proximity of a suitable habitat, and the martens' insatiable curiosity seemed responsible for their presence. Activity was restricted to areas with cover. Little arboreal activity was noted. Animals of both sexes were observed scent marking in the immediate vicinity of the station.

Authors' abstract.

Koehler, G.M. and M.G. Hornocker. 1977. Fire effects on marten habitat in the Selway-Bitterroot Wilderness. J. Wildl. Manage. 41:500-505.

An investigation in the Selway-Bitterroot Wilderness of north-central Idaho helped evaluate the effects of fire on marten (Martes americana) habitat and food sources. Voles (Microtinae) were the most abundant item in the marten diet, occurring in 79 percent of 129 marten scats. These were most abundant in mesic habitats. A total of 2,896 trap days during November 1973 through March 1974 and November and December 1974 resulted in 80 captures of 13 marten and 255 track observations. Marten used a variety of forest types. The highest activity when snow depths were normal was in stands having an Engelmann spruce/subalpine fir (Picea engelmanni/Abies lasiocarpa) overstory, canopy cover greater than 30 percent, mesic habitat type, and an overstory age greater than 100 years. The effects of fire on marten habitat and foods are discussed.

Author's abstract.

Lensink, C.J., R.O. Skoog, and J.L. Buckley. 1955. Food habits of marten in interior Alaska and their significance. J. Wildl. Manage. 19:364-368.

Marten food habits may vary with the habitat in which it exists. In Alaska, Clethrionomys rutilis and Microtus spp. were the most important food followed by berries and avian foods. A relative scarcity of varying hare and red squirrel in the study accounted for an extremely low use of these mammals in the marten diet. Author's abstract.

Marshall, W.H. 1951. Pine marten as a forest product. J. For. 49:899-905.

Members of the genus Martes are distributed around the world in association with northern coniferous forests. Despite serious over-trapping, marten pelts are still producing an income with practically no management. The present low populations of marten in North America are due to the ease of catching marten in steel traps and the low reproductive potential of the species. The beginning of the system which allows for cropping of fur on a sustained yield basis has been made in specific areas of Canada and the United States. The following steps could be taken to initiate marten management in a forested area:

1) Encouragement to integrate seasonal forestry employment with registered traplines.
2) Assuring trappers of opportunities for steady trapping on registered traplines providing the area isn't over-trapped.
3) Removal of all unauthorized cabins and controlled use of other cabins during winter and constant guarding against buying illegal furs.

Author's abstract.

Martell, A.M. and A. Radvanyi. 1977. Changes in small mammal populations after clearcutting of northern Ontario black spruce forest. Can. Field-Nat. 91:41-46.

Changes in small mammal populations on upland black spruce (Picea mariana) clearcuts near Manitouwadge, Ontario, were monitored between 1973 and 1975 by live-trapping. Additional clearcuts and uncut stands were sampled by dead-trapping in September 1975. The September density of mice and voles was similar during the first, second, and third year after clearcutting (13.0/ha, 11.6/ha, and 10.0/ha, respectively). Red-backed voles (Clethrionomys gapperi), likely common in uncut stands but increased on clearcuts until they predominated in the small mammal community by the end of the second harvest, and then declined markedly to rare status. Conversely, deer

mice (Peromyscus maniculatus) likely were scarce in uncut stands but increased on clearcuts until they predominated in the small mammal community by the end of the second summer after cutting. For less common species clearcut and uncut stands were compared. Meadow voles (Microtus pennsylvanicus) were more common on clearcuts than in uncut stands while the converse was true for rock voles (Microtus chrotorrhinus). Bog lemmings (Synaptomys cooperi) were taken only in uncut stands while heather voles (Phenacomys intermedius) and least chipmunks (Eutamias minimus) were captured only on clearcuts. Clearcutting of upland black spruce forest produced a dramatic change in the composition of the small mammal community but may have caused little change in density.

Authors' abstract.

Mech, L.D. and L.L. Rogers. 1977. Status, distribution, and movements of marten in northeastern Minnesota. U.S. For. Serv. Res. Pap. NC-143. 7pp.

The decline of martens in Minnesota is reviewed and a recent increase documented. Adjacent and partially over-lapping home ranges of 4.3 to 19.9 $km^2$ were determined by telemetry for a female and three males. Habitat use is described. If current trapping and timber management practices persist, martens should continue to increase.

More, G. 1978. Ecological aspects of food selection in pine marten (Martes americana). M.S. Thesis. Univ. of Alberta, Edmonton. 94pp.

A study of food selection in pine marten (Martes americana) was conducted in the southern Northwest Territories (60° 45' N, 116° 37' W) from 1974-75. Mammals were the major food source. Small mammals, notably boreal red-backed voles (Clethrionomys gapperi) and meadow voles (Microtus pennsylvanicus) were the principal species of marten diet. Red squirrels (Taniasciurus hudsonicus) and snowshoe hare (Lepus americanus) were taken infrequently. Deer mice (Peromyscus maniculatus) were rarely found in scats, despite their apparent abundance in the study area.

Summer, fall, and winter habitats that showed greater than expected use were mesic habitats, mostly coniferous and mixed deciduous stands of moderate to high stand density. Very open xeric, and open moist sites showed less than expected use. Marten had bimodal activity periods in the early morning and evening in summer. These periods of activity were modified in fall and winter. Marten were seldom active between mid-morning and late afternoon in summer and fall but were active during

the morning in winter. Changes in circadian rhythms may be attributable to changes in the physical environment such as day length.

Weather influenced marten activity to a variable extent. They tended to be active on overcast or rainy days and inactive on clear or snowy days.

Much of the observed food selection in marten is explained by the ecological availability of prey. The major ecological spacing mechanisms involved were temporal and spatial overlap of marten and their prey. C. gapperi exhibited the most extensive overlap both temporally and spatially, and occurred most frequently in marten scats. Spatial and temporal overlap was low between P. maniculatus and marten thus explaining the low occurrence of this species in marten diet despite their abundance in snap-trap samples.

Marten tended to specialize on small mammals, and obtained most of their food requirements from C. gapperi and M. pennsylvanicus. When populations of the principal small mammals were below normal or were unavailable, marten preyed on other species. Large male marten killed large species such as T. hudsonicus and L. americanus. Females and young marten may be unable to kill large prey with adequate success to maintain themselves and the populations of marten subsequently declined.

Marten predation had little impact on C. gapperi populations in years of average vole densities. Predation was high during the decline phase of voles in the winter and spring of 1974-75. However, C. gapperi numbers recovered to normal by fall 1975. Thus, marten predation cannot be considered a significant factor in microtine fluctuations despite heavy predation during the decline phase.

Edited Author's abstract.

Quick, H.F. 1953. Wolverine, fisher and marten studies in a wilderness region. Trans. N. Amer. Wildl. Conf. 18:513-532.

Marten used a variety of habitats throughout northeastern British columbia but avoided muskeg. Trapping does not adequately reflect true sex ratios of the population.

Raine, R.M. 1981. Winter food habits, responses to snow cover and movements of fisher (Martes pennanti) and marten (Martes americana) in southeastern Manitoba. M.Sc. Thesis, University of Manitoba, Winnipeg.

A trailing and radiotelemetry study of fisher and marten was conducted from August, 1978 to August, 1980 in the boreal forest of southeastern Manitoba.

Snowshoe hares composed 81% of the winter diet of fisher and 53% of the diet of marten. Marten displayed more subnivean and arboreal activity, and ate more microtines and squirrels than did fisher. Fisher ate marten twice. Both fisher and marten were found to pursue hares actively for distances of up to 1 km.

Fisher were found to be restricted by the soft, thick snow cover that was present during midwinter. Fewer tracks were observed at this time, and fisher travelled upon snowshoe hare trails and their own trails to a greater extent than in either

the early winter period of thin snow cover or the late winter period of crust conditions. Fisher were also found to walk through the snow cover and leave a body drag in midwinter.

Marten did not appear to be hindered by soft snow cover to the degree that fisher were. Marten tracks were encountered with equal frequency throughout the winter and they never left a body drag in the snow cover. They did travel upon hare trails and their own trails to a greater extent in the midwinter, but never as much as did fisher.

Two juvenile, female fisher had winter home ranges of from 15.0-20.5 $km^2$, while other juvenile females and males dispersed from the study area after their release.

One juvenile, male marten had a home range of 9.6 $km^2$ in early winter, while another wandered at random in late fall and early winter, but appeared to have a permanent home range of 8.1 $km^2$ by the following spring. A juvenile female marten had seasonal home ranges of from 6.0-8.4 $km^2$.

A fire that swept through the study area in May 1980 caused one male marten to disperse 61 km, while a female marten did not alter her home range during the 2 months that radio contact was maintained.

Author's abstract.

Raine, R.M. 1982. Ranges of juvenile fisher, Martes pennanti, and marten, Martes americana, in Southeastern Manitoba. Can. Field-Nat. 96:431-438.

A radio telemetry study of a resident population of Fisher and an invading population of Marten was conducted from August 1978 to August 1980, in the boreal forest of southeastern Manitoba. Two juvenile, female fisher had winter ranges of 15.0 and 20.5 $km^2$, while other juvenile females and males dispersed from the

study area after their release. One juvenile, male marten had a range of 9.6 $km^2$ in early winter, while another wandered at random in late fall and early winter, but had a range of 8.1 $km^2$ by the following spring. A juvenile, female marten had seasonal ranges varying from 6.0 to 8.4 $km^2$. A fire that swept through the study area in May 1980 perhaps caused one male marten to disperse 61 km, while a female marten did not alter her range during the two months that radio contact was maintained. Author's abstract.

Ramirez, P. Jr., and M. Hornocker. 1981. Small mammal populations in different-aged clearcuts in northwestern Montana. J. Mammal. 62:400-403.

Clearcuts provide diverse habitats for small mammals through different stages of succession much as wildfire formerly did. These diverse habitats support a diverse community of small mammals which form an abundant food source for various species of predators.

Robinson, W.B. 1953. Coyote control with compound 1080 stations in national forests. J. For. 51:880-885.

Possible impacts of coyote baiting on marten, weasels, mink, foxes, bears, and birds were investigated in the southwest U.S.A. Interpretations based on the literature were provided.

Soutiere, E.C. 1979. Effects of timber harvesting on marten in Maine. J. Wildl. Manage. 43:850-860.

The influence of timber harvesting upon marten (Martes a. americana) was studied in spruce, fir-hardwood forests in the Moosehead Lake Region, Maine, during 1974-77. Partial harvesting and commercial clear-cutting were examined. In the partially harvested forest, basal area was reduced by about 40%. In the commercial clear-cut forest, 50% of the forest was clear-cut and 25% was cut selectively. Density of adult, resident marten averaged 1.2/$km^2$ in the undisturbed and partially harvested forests, but was 0.4/$km^2$ in the commercial clear-cut forest. Home range lengths were longest in the commercial clear-cut forest. In undisturbed forests, marten preferred softwood-dominated mixed stands. In the partially harvested forest, tracks were found in all cover types in proportion to the occurrence of the cover types. Marten rarely used the 0- to 15-year old clear-cut areas, but the associated lightly cut hardwood stands and islands of uncut softwoods were heavily used. Of the more common foods eaten by marten, meadow voles (Microtus pennsylvanicus), ground nesting birds, and raspberries (Rubus idaeus) were more abundant in the harvested

forests, whereas red-backed vole (Clethrionomys gapperi) numbers were not affected by logging. Harvesting methods that maintain a residual stand of 20-50 $m^2$/ha basal area in pole and larger trees provide adequate habitat for marten. Clear-cuts up to 15 years old are poor marten habitat.

Steventon, J.D. 1979. Influence of timber harvesting upon winter habitat use by marten. M.S. Thesis, Univ. of Maine, Orono. 63p.

Winter habitat use by marten (Martes americana) was studied by radio telemetry and snow tracking on a commercially clear-cut spruce-fir-hardwood forest in Maine. About 1/3 of the area was 3-18 year old regenerating clear-cuts, 1/3 was uncut softwood stands, and the remainder was partially cut mixed stands (average basal area reduced 50%). Intensive study of 2 males and 1 female yielded 420 locations and 97 km of tracking. Clear-cuts were used less than their proportional occurrence within the study area or within marten home ranges. Uncut softwood stands and partially cut mixed stands were heavily used. Both males had home ranges of nearly 9.5 $km^2$ of which 35-40% were clear-cuts. These males often crossed clear-cuts to reach isolated patches of residual forest cover. Females were located only in large blocks of residual forest and had ranges as large as 2.5 $km^2$, with up to 25% in clear-cuts. The female that was intensively studied rarely crossed clear-cuts. Typical resting sites for marten were cavities in large decayed stumps or logs. Some potential impacts of intensive forestry on marten habitat are discussed.

Author's abstract.

Steventon, J.D. and J.T. Major. 1982. Marten use of habitat in a commercially clear-cut forest. J. Wildl. Manage. 46:175-182.

Habitat use by eastern marten (Martes americana) was studied in northern Maine where commercial clear-cutting had been conducted 3-18 years ago. Four adult resident marten were intensively studied through radiotelemetry and snow-tracking. Analysis of 1,734 radio locations and 97 km of winter snow-tracking indicated that uncut softwood islands and partially cut mixed stands were heavily used by marten during both summer and winter. Regenerating clear-cuts were generally used less than expected, although marten foraged there for red raspberries (Rubus idaeus) in late summer. Home ranges determined by radiotelemetry were several times larger than those obtained in the same area by live-trapping in an earlier study. The female, located mostly in a large block of uncut forest, had a home range of 2.0-2.5 $km^2$, of which 25% was clear-cut. The 3 males occupied home ranges of 5.0-10.0 $km^2$, 16-50% of which was in clear cuts. Winter resting sites of marten were cavities in large decayed stumps of logs. Marten rested in the crowns of conifers during the summer months.

Although marten relied on the uncut and partially cut stands within the commercially clear-cut forest, they were apparently able to tolerate and make seasonal use of extensive areas of regenerating clear-cuts within their home ranges.

Authors' abstract.

Strickland, M.A. and C.W. Douglas. 1984. The marten. Ontario Ministry of Natural Resources.

Synopsis of the natural history of the marten in Ontario.

Strickland, M.A., C.W. Douglas, M. Novak, and N.P. Hunziger. 1982. Marten (Martes americana). pp. 599-612 in Wild Mammals of North America, Johns Hopkins University Press, Baltimore, Maryland. J.A. Chapman and G.A. Feldhamer, Editors.

Detailed description of the natural history of the marten in North America.

Strickland, M.A. and C.W. Douglas. 1987. Marten. p. 531-546 In Novak, M., J.A. Baker, M.E. Obbard and B. Malloch eds. Wild furbearer management and conservation in North America. Ont. Trappers. Assoc. 1150 p.

Marten biology, management and taxonomy are described in detail along with discussions of economic importance.

Taylor, M.E. and N. Abrey. 1982. Marten (Martes americana) movements and habitat use in Algonquin Provincial Park, Ontario. Can. Field-Nat. 96:439-447.

The behavior of five male Marten (Martes americana) was studied between 1973 and 1975 using radio telemetry. They spent proportionately more time in predominantly coniferous habitats than in hardwood habitats. The maximum foraging area was 3.53 $km^2$. Individuals often moved rapidly about their foraging area; the fastest recorded speed was 7.2 km/h. Marten move from one foraging area to another for reasons other than food supply and do not always return. The marten were tracked simultaneously on several occasions and each moved quite differently. Marten seem to show mutual avoidance and their foraging areas do not usually overlap.

Authors' abstract.

Thompson, I.D. and P.W. Colgan 1987a. Optimal foraging by marten, (Martes americana): the role of large prey in winter. XVIII Congress I, I.V.G.B., Krakow. 9pp.

Marten (Martes americana) have been characterized as small mammal generalists or vole specialists. However, optimal foraging theory predicts neither, and that they would take larger more profitable prey. We used an ecological energetics approach to examine marten energy requirements and strategies to avoid thermal stress in winter. Marten activity was determined from radio-telemetry and kill rates found from following marten tracks. Diet choice from 273 carcasses indicated small prey accounted for 60-70% of prey by occurrence and the rest was larger prey (> 100 g). Conversion of prey types to energy contributed indicates that the contribution by large prey is most important. Energy requirements suggest that marten could not survive in winter solely by eating small rodents. Strategies used to compensate for thermoregulatory stress in winter included: reduced activity, resting in thermoneutral condition in dens, restricting activity to the warmest part of the day, and maximizing large prey in the diet.

Authors' abstract.

Thompson, I. D. and P.W. Colgan. 1987b. Effects of logging on home range characteristics and hunting activity of marten (Martes americana) in Ontario. XVIII Congress, I.V.G.B., Krakow 9pp.

A major impact on marten (Martes americana) habitat in Canada is timber harvesting. Attributes of home range and hunting activity of marten were compared in uncut and logged forest stands in north central Ontario. Home ranges in logged areas were significantly larger than in uncut areas for both sexes. Male and female ranges in logged sites were the same size while in uncut areas they differed significantly, with males having larger ranges. The number of core areas was similar for all animals but those in logged sites were located significantly farther apart than in uncut areas. Marten in logged areas travelled faster than those from uncut sites and spent a significantly greater proportion of time above mean speed, except in core areas where speed was the same as in uncut habitats. Marten in both types of site deposited scent at the same rate.

Marten were found to hunt logged and uncut areas in a similar manner. This suggests that despite habitat and prey changes owing to logging, animals are unable to adapt by altering their hunting methods. Curtailing of trapping in logged areas may permit facilitation of behaviors.

Authors' abstract.

Thompson, I.D. and P.W. Colgan. 1987c. Numerical responses of martens to a food shortage in northcentral Ontario. J. Wildl. Manage. 51(4):824-835.

Numerical responses of martens (Martes americana) to a synchronous decline of most prey species were studied from 1980 to 1985. Main prey species included snowshoe hare (Lepus americanus), red squirrels (Tamiasciurus hudsonicus), southern red-backed voles (Clethrionomys gapperi), deer mice (Peromyscus maniculatus), and ruffed grouse (Bonasa umbellus). Populations of these prey species were high in 1980-81 and substantially reduced from 1982 to 1985, except ruffed grouse, which were abundant in 1984-85. Responses of martens included reduced population density, enlarged home ranges, lower ovulation rates in females ages 1 and 2 years, reduced production of young, dispersal of formerly resident adults during the 2nd year of scarce food, and cannibalism. Dispersal of residents resulted in an unexpectedly high trapping success in 1983, suggesting that fur returns do not reflect changing population levels for marten. Male body weights did not differ among years but females weighed more in early winter of scarce food years compared to the same period when food was abundant ($P < 0.01$). Less mesenteric and renal fat was found on all martens during the first winter of scarce food ($P < 0.001$). We believe that a reservoir strategy for marten management can be an effective tool, but when food is low managers must account for larger home ranges and possible dispersal of residents by reducing harvest quotas.

Authors' abstract.

Weckwerth, R.P. and V.D. Hawley. 1962. Marten food habits and population fluctuations in Montana. J. Wildl. Manage. 26:55-74.

The relationships between marten population fluctuations, marten food habits and prey densities were investigated in Glacier National Park, Montana from 1952 through 1957. The major food items in the martens diet were mammals (93.3%), birds (12.0%), insects (19.0%), and fruits (29.2%). The major mammalian food items were Microtus spp. and Clethrionomys gapperi. Food items appeared to be taken in proportion to their relative abundance except for a few instances when use of a food was affected by availability, preference by marten, or availability and consumption of other foods.

The decline in marten population closely followed a decrease in small mammal density in 1954. The increase in small mammals in 1957 raised the carrying capacity and the marten population began to recover with the addition of both juveniles and adults.

Edited Authors' abstract.

Yeager, L.E. 1950. Implications of some harvest and habitat factors in pine marten management. Trans. 15th North Amer. Wildlife Conf. 319-334.

Marten are a significant economic resource in North America but timber harvest, fire, and forest diseases are making inroads on marten range. A discussion of implications of land use is presented.

Yeager, L.E. and J.D. Remington. 1956. Sight observations of Colorado martens. J. Mammal. 37(4):521-524.

A total of 66 marten observations were recorded but only 33 of these were considered to be reliable. Sightings were based on an actual sight record of an animal or a scat or a set of tracks. Most of the observations were made during the breeding season in mid-summer suggesting more diurnal activity at this time. However, observer activity is also at its heaviest during this time as well. Marten observations were associated by elevation and timber type. Sixty-three of 66 sight records were in the coniferous forest types above 8500 feet.